Chapter 5
Blind Detection of Additive Spread-Spectrum Watermarking in the Dual-Tree Complex Wavelet Transform Domain

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ABSTRACT

In this paper, the authors adapt two blind detector structures for additive spread-spectrum image watermarking to the host signal characteristics of the Dual-Tree Complex Wavelet Transform (DT-CWT) domain coefficients. The research is motivated by the superior perceptual characteristics of the DT-CWT and its active use in watermarking. To improve the numerous existing watermarking schemes in which the host signal is modeled by a Gaussian distribution, the authors show that the Generalized Gaussian nature of Dual-Tree detail subband statistics can be exploited for better detector performance. This paper finds that the Rao detector is more practical than the likelihood-ratio test for their detection problem. The authors experimentally investigate the robustness of the proposed detectors under JPEG and JPEG2000 attacks and assess the perceptual quality of the watermarked images. The results demonstrate that their alterations allow significantly better blind watermark detection performance in the DT-CWT domain than the widely used linear-correlation detector. As only the detection side has to be modified, the proposed methods can be easily adopted in existing DT-CWT watermarking schemes.

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INTRODUCTION

Watermarking has been proposed as a technology to ensure copyright protection by embedding an imperceptible, yet detectable signal in digital multimedia content such as images or video. Transform domains such as the DCT or DWT facilitate modeling human perception and permit selection of signal components which can be watermarked in a robust but unobtrusive way.

Loo (2000) first proposed to use Kingsbury's dual-tree complex wavelet transform (DT-CWT) (Kingsbury, 1998) for blind watermarking. The DT-CWT is a complex wavelet transform variant which is only four-times redundant in 2-D and offers approximate shift invariance together with the property of directional selectivity. Thus, it remedies two commonly-known shortcomings of the classic, maximally decimated DWT. Furthermore, it can be implemented very efficiently on the basis of four parallel 2-D DWTs.

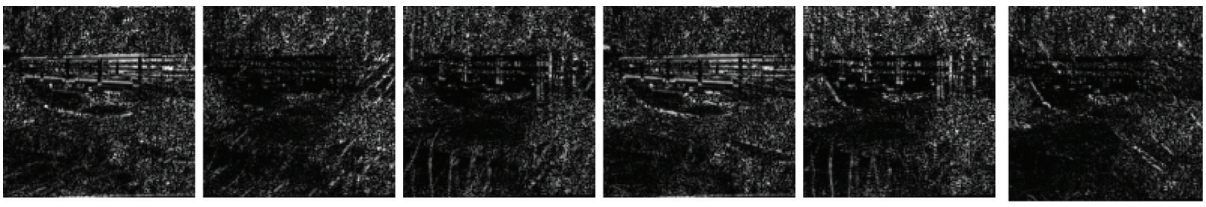
For these reasons, the DT-CWT domain has become a very popular choice for watermark embedding recently (Loo & Kingsbury, 2000; Woo et al., 2006; Earl & Kingsbury, 2003; Wang et al., 2007; Coria et al., 2008; Mabtoul et al., 2008; Mabtoul et al., 2009; Tang & Chen, 2009; Zhuang & Jiang, 2006). However, for blind watermarking detection, i.e. when detection is performed without reference to the unwatermarked host signal, the host interferes with the watermark signal. Hence informed embedding/coding techniques at the embedder side, e.g., ISS (Malvar & Florencio, 2003), and, at the detector side, accurate modelling of the host signal is crucial for the overall performance of a blind watermarking scheme. In this paper, we focus on improving the detector part.

In Section 2 we argue that the real and imaginary parts of DT-CWT subband coefficients can be accurately modeled by a Generalized Gaussian distribution (GGD). After reviewing the literature on complex wavelet domain watermarking in Section 3, we adopt and compare the applicability of two blind spread-spectrum watermark detectors in Section 4 which exploits the DT-CWT domain subband statistics. We experimentally compare the detection performance of the proposed schemes also under JPEG and JPEG2000 attacks and assess the perceptual quality of DT-CWT embedding in Section 5. Section 6 offers concluding remarks.

2. DT-CWT SUBBAND STATISTICS

In order to obtain a good signal detector in noise, i.e. the host signal for blind watermarking in the absence of attacks, we have to find a reasonable noise model first. By employing a J-scale 2-D DT-CWT we obtain six complex subbands per decomposition level, oriented along approximately +/- 15, +/- 45, +/- 75 degree. To visualize the directional selectivity, Figure 1 shows the magnitude of the six complex detail subbands at level two of the decomposed Bridge image (see Figure 1).

Figure 1. Complex coefficient magnitudes of the 2nd level detail subbands with the MLEs of the GGD's shape parameter β fitted to the marginal distributions of concatenated real and imaginary parts



β = 0.94 β=0.81 β = 0.81 β=0.82 β = 0.81 β=0.93